PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-121314

(43)Date of publication of application : 08.05.2001

(51)Int.Cl. B23B 27/14
C23C 14/06

(21)Application number : 11-307741

(22)Date of filing : 28.10.1999

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(54) HARD FILM-COATED TOOL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a hard film-coated tool that involves an improvement in the oxidation resistance and coefficient of friction of its hard film and is applicable to dry and high-speed cutting.

SOLUTION: The hard film-coated tool has a hard film of an at least two- alternated lamination of an A layer having chemical composition represented by (Ti1-a-bSiaVb)(NxO1-x) wherein $0 \leq a \leq 0.5$, $0.1 \leq b \leq 0.7$ and $0.5 \leq x \leq 0.999$, and a B layer having chemical composition. represented by (TiAl)(NyO1-y) wherein $0.5 \leq y \leq 0.999$.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the hard-anodic-oxidation-coatings covering tool used for cutting, such as a metallic material.
[0002]
[Description of the Prior Art] Generally TiN, TiCN, TiAlN, etc. are used as a coat of a hard-anodic-oxidation-coatings covering tool. Since TiN is comparatively excellent in oxidation resistance, the outstanding abrasion resistance is not only shown to the face wear of the tool produced by generation of heat at the time of cutting, but it is the description that adhesion with a base material is also good. TiCN shows the property which was excellent under the cutting conditions accompanied by adhesion to flank wear and a tool in order to show a high degree of hardness and low friction compared with TiN. It stopped however, showing sufficient oxidation resistance and abrasion resistance by the above-mentioned hard anodic oxidation coatings to the high speed inclination of the cutting speed aiming at the high promotion of efficiency of metalworking.
[0003] The TiAlN coat which the research which raises the oxidation resistance of a coat more is made, consequently is represented by JP,62-56565,A and JP,2-194159,A from such a background is developed, and it is applied to the cutting tool. Although a TiAlN coat changes with component ratios of Ti and aluminum contained in the coat, since oxidation resistance is excellent compared with said TiN and TiCN, the edge of a blade raises [the Vickers hardness number of outlines 2300-2800 / not only /, but] the engine performance of a cutting tool remarkably in cutting of the temper material which reaches an elevated temperature.
[0004]
[Problem(s) to be Solved by the Invention] However, are seriously taken on an environmental problem, the operating environment of a cutting tool is still crueller, and the present condition is that it is not satisfied with the oxidation resistance of a TiAlN coat of cutting in dry type enough in addition to the inclination which cutting speed accelerates further in recent years.
[0005] Coefficient of friction of a coat and oxidation were specifically considered mainly, and this invention person clarified the fault which happens first when each conventional coat is used by the severe condition in recent years, and the point which should be improved.
[0006] As a result of measuring coefficient of friction of the various hard anodic oxidation coatings at the time of making partner material into SKD11 temper material, and making relative velocity into 100 m/min, for TiN, 0.6 and TiCN were [0.3 and TiAlN] 0.7. In this, TiCN with the smallest coefficient of friction shows the outstanding engine performance by dry type cutting with comparatively low cutting speed. However, the property of a coat is not fully demonstrated under the high-speed-cutting condition to which the edge of a blade reaches an elevated temperature more. It turned out that this reason is for forming Ti oxide with a TiCN coat very porous on a coat front face at about 500 degrees C.
[0007] Then, the oxidation initiation temperature of each coat was investigated. According to this invention person's etc. research, the oxidation initiation temperature of each coat in air improves at about

750-850 degrees C to being about 500 degrees C at TiN according to the addition of aluminum by the TiAlN coat by about 600 degrees C and TiCN.

[0008] Since the edge-of-a-blade temperature of the tool which oxidation initiation temperature uses in dry type high-speed-cutting processing of temper material also by comparatively high TiAlN in this reached an elevated temperature 900 degrees C or more, it turned out that it cannot deal with improvement in the speed of cutting speed enough. And it turned out that exfoliation generates a TiAlN coat easily at the time of actual cutting since it forms precise aluminum oxidation protective coat in the outermost layer by extroversion diffusion of aluminum, and porous Ti oxide is formed directly under aluminum oxide in a static oxidation test, although the comparatively excellent oxidation resistance was shown. From the above examination, it was thought first that hard anodic oxidation coatings needed oxidation-resistant to be improved.

[0009] Moreover, also in the dry type high speed cutting of non-temper material, the TiAlN coat with large coefficient of friction like the above in addition to the rise of the edge-of-a-blade temperature of a tool has the intense adhesion of the **-ed material to a lifting and a tool cutting edge in **-ed material and a chemical reaction. The coat which **-ed material agglutinated became clear [that drop out easily and sufficient abrasion resistance is not obtained, either]. From this knowledge, it was thought that hot coefficient of friction also needed to be decreased.

[0010] Let it be a technical problem for this invention to improve the oxidation resistance of hard anodic oxidation coatings, and coefficient of friction, and to offer the hard-anodic-oxidation-coatings covering tool corresponding to dry-type-izing of cutting, and improvement in the speed in view of such a situation.

[0011]

[Means for Solving the Problem] The result to which the artificer etc. carried out examination detailed about the effect of various elements affect the oxidation resistance of hard anodic oxidation coatings, abrasion resistance, and coefficient of friction, and the layer structure of a coat, hard anodic oxidation coatings (NxO 1-x (Ti1-a-bSiaVb)) -- however, with 0<=a<=0.5, 0.1<=b<=0.7, 0.5<=x<=0.999, and the A horizon that comes out and consists of chemical composition shown (TiAl) However, header this invention was reached [that the engine performance of a cutting tool becomes very good in dry type high-speed-cutting processing, and] by considering as the hard-anodic-oxidation-coatings covering tool which carried out the laminating of the B horizon which consists of chemical composition shown by 0.5<=y<=0.999 more than two-layer by turns (NyO1-y). Furthermore, as for the above-mentioned hard anodic oxidation coatings, being covered with physical vapor deposition is desirable.

[0012]

[Function] An operation of each of that configuration is first described in detail about the A horizon of a publication among a claim. (Ti1-a-bSiaVb) However, Ti system acid nitride which consists of 0<=a<=0.5, 0.1<=b<=0.7, and 0.5<=x<=0.999 has coefficient of friction very as low as about about 0.4 in the inside of air (NxO 1-x). This reduced cutting temperature remarkably and checked controlling promotion of oxidation. This is mainly based on the addition effectiveness of V.

[0013] Furthermore, depending on the addition of Si, it found out the oxidation resistance of the coat itself not only improves, but that oxidation could not advance easily at the time of the use as an actual cutting tool. This is for forming the very precise oxide layer containing Si or V used as an oxidation protective coat in the hard-anodic-oxidation-coatings outermost surface after oxidation of Ti system acid nitride, and not forming porous Ti oxide leading to [of an oxidation protective coat] exfoliation directly under it. Therefore, oxidation initiation temperature is extremely elevated-temperature-ized compared with the conventional TiAlN coat. Moreover, oxidation resistance improves further by carrying out optimum dose addition of the oxygen other than nitrogen as a nonmetallic element.

[0014] The presentation of the metallic element of the A horizon which constitutes the hard anodic oxidation coatings of this invention needs a and to satisfy a formula b each called 0 <=a<=0.5 and 0.1<=b<=0.7 in (Ti1-a-bSiaVb). When the value of a exceeds 0.5, the internal stress in a coat induces the autoclasis greatly, and the above-mentioned oxidation resistance is not shown. When low coefficient of friction with the value of b sufficient by less than 0.1 cannot be obtained and 0.7 is surpassed, the fall

of the hardness of a coat becomes remarkable and it becomes impossible moreover, to be equal to the use as a cutting tool.
[0015] Moreover, in the case of the acid nitride concerning the above-mentioned A horizon, it is required to satisfy 0.5<=x<=0.999 at NxO 1-x, and when the value of x is less than 0.5, the degree of hardness of a coat falls remarkably and does not show sufficient cutting-ability ability. On the other hand, if 0.999 is exceeded, the contribution to the anti-oxidation disposition top of a coat decreases, and it is not desirable.
[0016] Next, an operation of a B horizon is described. Although the above-mentioned A horizon has static and the oxidation resistance, and low friction which were excellent under the dynamic condition, its internal stress of a coat is high and it does not show cutting-ability ability sufficient as a single coat. Then, it is necessary to use together the B horizon which has the outstanding adhesion, abrasion resistance, and oxidation resistance. It is required to be satisfied with the presentation (NyO(TiAl)1-y) of this B horizon of 0.5<=y<=0.999. When the value of y is less than 0.5, the degree of hardness of a coat falls remarkably and does not show sufficient abrasion resistance. On the other hand, if 0.999 is exceeded, the contribution of oxygen to the anti-oxidation disposition top of a coat decreases, and it is not desirable.
[0017] It becomes possible [obtaining the cutting tool corresponding to dry-type high speed cutting very importantly consequently] to carry out the laminating of the B horizon which has the abrasion resistance and the oxidation resistance of adhesion with a base and the coat itself with sufficient balance in this invention, and the A horizon which is excellent in oxidation resistance and low friction more than two-layer desirably by turns, respectively as mentioned above.
[0018] Although it is not limited especially about the covering approach, when the thermal effect to a covering base material, the fatigue strength of a tool, the adhesion of a coat, etc. are taken into consideration, as for the hard-anodic-oxidation-coatings covering tool of this invention, it is desirable that it is the physical vapor deposition which impresses bias voltage to a covering base side, such as arc discharge method ion plating to which compressive stress remains to the coat which could cover with low temperature comparatively and was covered, or sputtering. This invention is explained based on an example below.
[0019]
[Example] The various targets made from an alloy which are the evaporation sources of a metal component using an arc ion plating system, And that by which the target coat is obtained from N2 gas which is reactant gas, and N2 / O2 mixed gas is chosen. 2 cutting-edge end mill with an outer diameter of 10mm which is a covering base under conditions of the covering base temperature of 400 degrees C, and 3.0Pa of reagent-gas-pressure force made from cemented carbide, The potential of -150V was impressed to 6 cutting-edge end mill with an outer diameter of 8mm made from cemented carbide, and the insertion made from cemented carbide, and membranes were formed so that the thickness of all coats might be set to 4 micrometers. First, membrane formation sequence formed the A horizon for the B horizon next, and repeated this according to the number of laminatings. The presentation of the A horizon of each sample and a B horizon and the total number of layers (A number-of-layers +B number of layers) are shown in Table 1.
[0020]
[Table 1]

		A層 組成	B層 組成	総層数 (A層数 +B層数)	2枚刃 エンドミル 工具寿命(m)	6枚刃 エンドミル 工具寿命(m)	インサート 工具寿命 (m)
本発明例	1	$(Ti_{0.46}Si_{0.03}V_{0.51})(N_{0.86}O_{0.14})$	$(TiAl)(N_{0.78}O_{0.22})$	2	122.75	34.75	2.96
	2	$(Ti_{0.45}Si_{0.11}V_{0.44})(N_{0.97}O_{0.03})$	$(TiAl)(N_{0.98}O_{0.02})$	2	122.50	34.00	3.11
	3	$(Ti_{0.45}Si_{0.48}V_{0.07})(N_{0.83}O_{0.17})$	$(TiAl)(N_{0.88}O_{0.12})$	2	127.50	36.25	3.10
	4	$(Ti_{0.84}Si_{0.06}V_{0.10})(N_{0.95}O_{0.05})$	$(TiAl)(N_{0.98}O_{0.02})$	2	122.50	34.75	3.10
	5	$(Ti_{0.31}Si_{0.04}V_{0.65})(N_{0.99}O_{0.01})$	$(TiAl)(N_{0.77}O_{0.23})$	2	122.50	32.75	3.05
	6	$(Ti_{0.45}Si_{0.01}V_{0.54})(N_{0.80}O_{0.20})$	$(TiAl)(N_{0.95}O_{0.05})$	2	124.50	34.50	3.02
	7	$(Ti_{0.35}Si_{0.11}V_{0.54})(N_{0.53}O_{0.47})$	$(TiAl)(N_{0.80}O_{0.20})$	4	125.75	34.50	2.98
	8	$(Ti_{0.43}Si_{0.03}V_{0.54})(N_{0.999}O_{0.001})$	$(TiAl)(N_{0.997}O_{0.003})$	2	124.50	33.75	3.11
	9	$(Ti_{0.50}Si_{0.04}V_{0.46})(N_{0.88}O_{0.12})$	$(TiAl)(N_{0.88}O_{0.12})$	2	126.75	35.50	2.98
	10	$(Ti_{0.49}V_{0.51})(N_{0.996}O_{0.004})$	$(TiAl)(N_{0.93}O_{0.07})$	2	117.50	28.75	2.25
	11	$(Ti_{0.45}V_{0.55})(N_{0.83}O_{0.17})$	$(TiAl)(N_{0.79}O_{0.21})$	2	115.50	27.50	2.15
	12	$(Ti_{0.44}V_{0.56})(N_{0.94}O_{0.06})$	$(TiAl)(N_{0.81}O_{0.19})$	2	118.75	28.25	2.11
	13	$(Ti_{0.51}V_{0.49})(N_{0.52}O_{0.48})$	$(TiAl)(N_{0.997}O_{0.003})$	2	109.50	27.75	2.20
	14	$(Ti_{0.86}V_{0.14})(N_{0.98}O_{0.02})$	$(TiAl)(N_{0.79}O_{0.21})$	8	110.75	28.50	1.92
	15	$(Ti_{0.54}V_{0.46})(N_{0.82}O_{0.18})$	$(TiAl)(N_{0.89}O_{0.11})$	2	107.50	27.75	1.99
	16	$(Ti_{0.35}V_{0.65})(N_{0.999}O_{0.001})$	$(TiAl)(N_{0.997}O_{0.003})$	6	98.75	25.75	2.12
	17	$(Ti_{0.47}V_{0.53})(N_{0.97}O_{0.03})$	$(TiAl)(N_{0.58}O_{0.42})$	10	103.50	26.75	2.15
	18	$(Ti_{0.40}V_{0.60})(N_{0.97}O_{0.03})$	$(TiAl)(N_{0.999}O_{0.001})$	2	95.65	24.75	1.95
	19	$(Ti_{0.51}V_{0.49})(N_{0.92}O_{0.08})$	$(TiAl)(N_{0.81}O_{0.19})$	16	102.25	26.25	1.96
比較例	20	$(Ti_{0.07}Si_{0.90}V_{0.03})(N_{0.93}O_{0.07})$	$(TiAl)(N_{0.66}O_{0.34})$	2	45.50	9.75	1.12
	21	$(Ti_{0.05}Si_{0.05}V_{0.90})(N_{0.58}O_{0.42})$	$(TiAl)(N_{0.81}O_{0.19})$	2	45.75	8.75	1.08
	22	$(Ti_{0.90}Si_{0.08}V_{0.02})(N_{0.65}O_{0.35})$	$(TiAl)(N_{0.77}O_{0.23})$	5	58.50	8.50	1.09
	23	$(Ti_{0.02}V_{0.98})(N_{0.83}O_{0.17})$	$(TiAl)(N_{0.96}O_{0.04})$	7	46.75	9.80	1.12
	24	$(Ti_{0.99}V_{0.01})(N_{0.83}O_{0.17})$	$(TiAl)(N_{0.68}O_{0.32})$	2	58.50	8.75	0.85
	25	$(Ti_{0.57}V_{0.43})(N_{0.14}O_{0.86})$	$(TiAl)(N_{0.18}O_{0.82})$	6	36.75	5.25	0.55
	26	$(Ti_{0.75}V_{0.25})(N_{1.00})$	$(TiAl)(N_{1.00})$	2	61.25	11.50	1.24
	27	$(Ti_{0.56}Si_{0.26}V_{0.18})(N_{1.00})$	$(TiAl)(N_{1.00})$	2	60.50	12.25	1.27
	28	$(Ti_{0.50}Si_{0.28}V_{0.22})(N_{1.00})$	$(TiAl)(N_{0.95}O_{0.05})$	2	61.50	10.75	1.09
	29	$(Ti_{0.02}V_{0.98})(N_{0.54}O_{0.46})$	−	1	22.50	2.25	0.77
	30	$(Ti_{0.15}Si_{0.46}V_{0.39})(N_{0.78}O_{0.22})$	−	1	18.50	3.25	0.25
	31	−	$(TiAl)(N_{0.95}O_{0.05})$	1	57.75	13.50	1.35
従来例	32	$(Ti_{1.00})(N_{1.00})$		1	31.50	4.50	1.12
	33	$(Ti_{1.00})(C_{0.75}N_{0.25})$		1	46.50	4.20	1.46
	34	$(Ti_{0.49}Al_{0.51})(N_{1.00})$		1	42.50	12.75	1.35

[0021] The cutting trial was performed using the hard-anodic-oxidation-coatings covering end mill and hard-anodic-oxidation-coatings covering insertion which were obtained. The tool life was made into the length of cut when a tool becomes cutting impossible by a chip or wear of the edge of a blade etc. A cutting item is shown below.
[0022] Two-sheet cutting-edge end mill cutting conditions were taken as side-face cutting down cutting, **-ed material S50C (hardness 220HB), slitting Ad10 mmxRd1mm, cutting speed 250 m/min, delivery 0.06 mm/tooth, and the Ayr blow use.
[0023] Six-sheet cutting-edge end mill cutting conditions were taken as side-face cutting down cutting, ** material SKD 11 (hardness 62HRC)-ed, slitting Ad8 mmxRd0.4mm, cutting speed 150 m/min delivery 0.03 mm/tooth, and the Ayr blow use.
[0024] Insertion cutting conditions were taken as tool configuration SEE42TN, beveling processing with a width [of 100mm] x die length of 250mm, ** material SKD 61 (hardness 45HRC)-ed, 2.0mm of slitting, cutting speed 150 m/min, delivery 0.15 mm/rev, and dry type cutting. A test result is written together to Table 1.
[0025] The examples 20 and 21 of a comparison are examples of a comparison when there are too many amounts of Si and V respectively, and are short by coat exfoliation. [of a tool life] It is an example of a

comparison when there are too few amounts of V, and the example 22 of a comparison does not have the enough oxidation resistance of a coat, and is short. [of a tool life] It is an example of a comparison when there are too many amounts of V, and the example 23 of a comparison has the remarkable degree-of-hardness fall of a coat, and is [flank wear is large and] bad. [of abrasion resistance] In connection with the edge-of-a-blade temperature rise by friction, joining happens in an example when the example 24 of a comparison has too few amounts of V, and a surface to be machined does not show a dry area and sufficient abrasion resistance. The example 25 of a comparison is the case where there are too many amounts of oxygenation, and sufficient coat degree of hardness is not obtained, but flank wear becomes large, and it is short. [of a life] Although the amount of Si and V is the range in a claim, it is an example of a comparison when O is not added by an A horizon or the B horizon, and as compared with the example of this invention, its abrasion resistance is not [the examples 26, 27, and 28 of a comparison] enough. Although the examples 29 and 30 of a comparison were the single coats of an A horizon, exfoliation of a coat arose at an early stage, and they became a short life. Although the example 31 of a comparison is the single coat of a B horizon, its abrasion resistance is not enough.
[0026] A tool life improves remarkably synthetically, without wear advancing rapidly by exfoliation, since the B horizon which there were also few rises of the temperature the example of this invention is excellent in the dynamic oxidation resistance at the time of using it as a tool of hard anodic oxidation coatings, and according to friction, and took into consideration the balance of internal stress, the adhesion force, hardness, and toughness to these is used together. This invention corresponds to dry type high-speed-cutting processing enough.
[0027]
[Effect of the Invention] like the above, since [/ the oxidation resistance and low friction which were excellent compared with the conventional covering tool], in dry type high-speed-cutting processing, it is markedly alike, a long tool life is acquired, and the hard-anodic-oxidation-coatings covering tool of this invention is very effective in improvement in the productivity in cutting.

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CLAIMS

[Claim(s)]
[Claim 1] In the hard-anodic-oxidation-coatings covering tool which comes to prepare hard anodic oxidation coatings in a base front face these hard anodic oxidation coatings (NxO 1-x (Ti1-a-bSiaVb)) however, with 0<=a<=0.5, 0.1<=b<=0.7, 0.5<=x<=0.999, and the A horizon that comes out and consists of chemical composition shown (TiAl) However, the hard-anodic-oxidation-coatings covering tool characterized by carrying out the laminating of the B horizon which consists of chemical composition shown by 0.5<=y<=0.999 more than two-layer by turns (NyO1-y).

[Translation done.]

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 2001121314
PUBLICATION DATE : 08-05-01

APPLICATION DATE : 28-10-99
APPLICATION NUMBER : 11307741

APPLICANT : HITACHI TOOL ENGINEERING LTD;

INVENTOR : ISHIKAWA TAKASHI;

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(19)日本国特許庁（JP）　(12) 公開特許公報（A）　(11)特許出願公開番号
特開2001－121314
（P2001－121314A）
(43)公開日　平成13年5月8日(2001.5.8)

(51)Int.Cl.⁷	識別記号	FI	テーマコード(参考)
B23B 27/14		B23B 27/14	A 3C046
C23C 14/06		C23C 14/06	P 4K029

審査請求 未請求 請求項の数1 OL (全 5 頁)

(21)出願番号　特願平11－307741
(22)出願日　平成11年10月28日(1999.10.28)

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Fターム(参考) 3C046 FF02 FF09 FF10 FF16
4K029 AA02 AA21 BA58 BA60 BB02
BC01 BC02 BD05 CA03 CA05

(54)【発明の名称】 硬質皮膜被覆工具

(57)【要約】
【目的】硬質皮膜被覆工具において、硬質皮膜の耐酸化性と摩擦係数を改善し、切削加工の乾式化、高速化に対応する硬質皮膜被覆工具を提供する。
【構成】硬質皮膜被覆工具において該硬質皮膜は（Ti1－a－bSiaVb）（NxO1－x）、但し、0≦a≦0．5、0．1≦b≦0．7、0．5≦x≦0．999、で示される化学組成からなるA層と、（TiAl）（NyO1－y）、但し0．5≦y≦0．999で示される化学組成からなるB層を交互に2層以上積層して構成する。

【特許請求の範囲】

【請求項1】 基体表面に硬質皮膜を設けてなる硬質皮膜被覆工具において、該硬質皮膜は(Ti1-a-bSiaVb)(NxO1-x)、但し、0≦a≦0.5、0.1≦b≦0.7、0.5≦x≦0.999、で示される化学組成からなるA層と、(TiAl)(NyO1-y)、但し0.5≦y≦0.999で示される化学組成からなるB層を交互に2層以上積層したことを特徴とする硬質皮膜被覆工具。

【発明の詳細な説明】

【0001】

【発明が属する技術分野】本発明は、金属材料等の切削加工に使用される硬質皮膜被覆工具に関するものである。

【0002】

【従来の技術】硬質皮膜被覆工具の皮膜としてTiN、TiCN、TiAlN等が一般的に用いられている。TiNは比較的耐酸化性に優れるため、切削時の発熱によって生じる工具のすくい面摩耗に対して、優れた耐摩耗性を示すだけでなく、母材との密着性も良好であることが特徴である。TiCNは、TiNに比べ高硬度かつ低摩擦を示すため、逃げ面摩耗および工具に凝着を伴う切削条件下においては、優れた特性を示す。しかしながら、金属加工の高能率化を目的とした切削速度の高速化傾向に対し、上記硬質皮膜では、十分な耐酸化性、耐摩耗性を示さなくなった。

【0003】この様な背景から、皮膜の耐酸化性をより向上させる研究がなされ、その結果、特開昭62-56565号、特開平2-194159号に代表されるTiAlN皮膜が開発され切削工具に適用されている。TiAlN皮膜は、その皮膜中に含有するTiとAlの成分比率により異なるものの、概略2300~2800のビッカース硬さを有すだけではなく、耐酸化性が、前記TiN、TiCNに比べ優れるため、刃先が高温に達する調質材の切削においては、切削工具の性能を著しく向上させるものである。

【0004】

【発明が解決しようとする課題】しかしながら、近年では切削速度が更に高速化する傾向に加え、乾式での切削加工が環境問題上重要視され、切削工具の使用環境はますます苛酷なものとなってきており、TiAlN皮膜の耐酸化性では十分満足されないのが現状である。

【0005】本発明者はまず、従来の各皮膜を近年の過酷な条件で使用した場合に起こる不具合、具体的には皮膜の摩擦係数と酸化を主に検討し、改善すべき点を明らかにした。

【0006】相手材をSKD11調質材、相対速度を100m/minとした場合の各種硬質皮膜の摩擦係数を測定した結果、TiNが0.6、TiCNが0.3、TiAlNが0.7であった。このなかでもっとも摩擦係数が小さいTiCNは比較的切削速度の低い乾式切削では優れた性能を示す。しかしながら刃先がより高温に達する高速切削条件下においては、皮膜の特性が十分に発揮されない。この理由は、TiCN皮膜は500℃程度で皮膜表面に非常にポーラスなTi酸化物を形成するためであることが判った。

【0007】そこで各皮膜の酸化開始温度を調査した。本発明者等の研究によれば、空気中における各皮膜の酸化開始温度はTiNでは約600℃、TiCNでは約500℃であるのに対し、TiAlN皮膜ではAlの添加量に応じて約750~850℃に向上する。

【0008】このなかで酸化開始温度が比較的高いTiAlNでも、調質材の乾式高速切削加工においては使用する工具の刃先温度が900℃以上の高温に達するため、切削速度の高速化に十分対応できないことが判った。しかも、TiAlN皮膜は静的酸化試験では、Alの外向拡散により最表層に緻密なAl酸化保護膜を形成し、比較的優れた耐酸化性を示したものの、ポーラスなTi酸化物が、Al酸化物直下に形成されるため、実際の切削時には容易に剥離が発生してしまうことが判った。以上の検討より、先ず硬質皮膜の耐酸化性の改善が必要であると思われた。

【0009】また、非調質材の乾式高速切削においても、工具の刃先温度の上昇に加え、前記の如く摩擦係数の大きいTiAlN皮膜は、被削材と化学反応を起こし、工具切れ刃への被削材の凝着が激しい。被削材が凝着した皮膜は、容易に脱落してしまい十分な耐摩耗性が得られないことも明らかとなった。この知見より、高温における摩擦係数の低減も必要であるように思われた。

【0010】本発明はこうした事情に鑑み、硬質皮膜の耐酸化性と摩擦係数を改善し、切削加工の乾式化、高速化に対応する硬質皮膜被覆工具を提供することを課題とする。

【0011】

【課題を解決するための手段】発明者等は、硬質皮膜の耐酸化性、耐摩耗性、摩擦係数に及ぼす、種々な元素の影響および皮膜の層構造について詳細な検討を行った結果、硬質皮膜を、(Ti1-a-bSiaVb)(NxO1-x)、但し、0≦a≦0.5、0.1≦b≦0.7、0.5≦x≦0.999、で示される化学組成からなるA層と、(TiAl)(NyO1-y)、但し0.5≦y≦0.999で示される化学組成からなるB層を交互に2層以上積層した硬質皮膜被覆工具とすることによって、乾式高速切削加工において切削工具の性能が極めて良好となることを見出し本発明に到達した。更に上記硬質皮膜は、物理蒸着法により被覆されることが望ましい。

【0012】

【作用】はじめに請求項中記載のA層に関して、その各構成の作用について詳しく述べる。(Ti1-a-bS

ｉａＶｂ）（ＮｘＯ１－ｘ）、但し、０≦ａ≦０．５、０．１≦ｂ≦０．７、０．５≦ｘ≦０．９９９からなる、Ｔｉ系酸窒化物は、空気中での摩擦係数が約０．４程度と非常に低い。このことが切削温度を著しく低減させ、酸化の促進を抑制することを確認した。これは主にＶの添加効果によるものである。

【００１３】さらに、Ｓｉの添加量に依存して、皮膜自体の耐酸化性が向上するのみならず、実際の切削工具としての使用時においても酸化が進行しにくいことを見出した。これはＴｉ系酸窒化物の酸化後の硬質皮膜最表面に酸化保護膜となるＳｉまたはＶを含有する非常に緻密な酸化物層を形成し、その直下に酸化保護膜の剥離原因となるポーラスなＴｉ酸化物を形成しないためである。従って、酸化開始温度は従来のＴｉＡｌＮ皮膜に比べて極めて高温化する。また、非金属元素として窒素の他に酸素を適量添加することで耐酸化性がさらに向上する。

【００１４】本発明の硬質皮膜を構成するＡ層の金属元素の組成は、（Ｔｉ１－ａ－ｂＳｉａＶｂ）においてａ、ｂそれぞれ０≦ａ≦０．５、０．１≦ｂ≦０．７という式を満足させることが必要である。ａの値が０．５を超える場合、皮膜中の内部応力が大きく自己破壊を誘発し、前述の耐酸化性を示さない。またｂの値が０．１未満では十分な低摩擦係数を得られず、また０．７をこえると、皮膜の硬さの低下が顕著になり、切削工具としての使用に耐えられなくなる。

【００１５】また、上記Ａ層に係る酸窒化物の場合、ＮｘＯ１－ｘで０．５≦ｘ≦０．９９９を満足することが必要であり、ｘの値が０．５未満の場合は、皮膜の硬度が著しく低下し十分な切削性能を示さない。一方、０．９９９を超えると皮膜の耐酸化性向上に対する寄与が少なくなり、望ましくない。

【００１６】次にＢ層の作用について述べる。上記Ａ層は、静的および動的条件下において優れた耐酸化性、低摩擦を有すものの、皮膜の内部応力が高く、単一皮膜としては十分な切削性能を示さない。そこで、優れた密着性、耐摩耗性、耐酸化性を有するＢ層を併用する必要がある。このＢ層の組成は、（ＴｉＡｌ）（ＮｙＯ１－ｙ）で０．５≦ｙ≦０．９９９を満足することが必要である。ｙの値が０．５未満の場合は、皮膜の硬度が著しく低下してしまい十分な耐摩耗性を示さない。一方、０．９９９を超えると皮膜の耐酸化性向上に対する酸素の寄与が少なくなり、望ましくない。

【００１７】以上のように本発明においては、基体との密着性、皮膜自体の耐摩耗性および耐酸化性をバランス良く有すＢ層と、耐酸化性、低摩擦に優れるＡ層を交互に、望ましくはそれぞれ２層以上積層することが極めて重要であり、その結果、乾式の高速切削に対応する切削工具を得ることが可能となる。

【００１８】本発明の硬質皮膜被覆工具は、その被覆方法については、特に限定されるものではないが、被覆母材への熱影響、工具の疲労強度、皮膜の密着性等を考慮した場合、比較的低温で被覆でき、被覆した皮膜に圧縮応力が残留するアーク放電方式イオンプレーティング、もしくはスパッタリング等の被覆基体側にバイアス電圧を印加する物理蒸着法であることが望ましい。以下本発明を実施例に基づいて説明する。

【００１９】

【実施例】アークイオンプレーティング装置を用い、金属成分の蒸発源である各種合金製ターゲット、ならびに反応ガスであるＮ２ガス、Ｎ２／Ｏ２混合ガスから目的の皮膜が得られるものを選択し、被覆基体温度４００℃、反応ガス圧力３．０Ｐａの条件下にて、被覆基体である外径１０ｍｍの超硬合金製２枚刃エンドミル、外径８ｍｍの超硬合金製６枚刃エンドミルおよび超硬合金製インサートに－１５０Ｖの電位を印加し、全皮膜の厚みが４μｍとなるように成膜した。成膜順序は先ずＢ層を、次にＡ層を成膜し、積層数に応じてこれを繰り返した。各試料のＡ層、Ｂ層の組成、総層数（Ａ層数＋Ｂ層数）を表１に示す。

【００２０】

【表１】

		A層 組成	B層 組成	総層数 (A層数 +B層数)	2枚刃 エンドミル 工具寿命(m)	6枚刃 エンドミル 工具寿命(m)	インサート 工具寿命 (m)
本発明例	1	(TiSiV)(NO)	(TiAl)(NO)	2	122.75	34.75	2.96
	2	(TiSiV)(NO)	(TiAl)(NO)	2	122.50	34.00	3.11
	3	(TiSiV)(NO)	(TiAl)(NO)	2	127.50	36.25	3.10
	4	(TiSiV)(NO)	(TiAl)(NO)	2	122.50	34.75	3.10
	5	(TiSiV)(NO)	(TiAl)(NO)	2	122.50	32.75	3.05
	6	(TiSiV)(NO)	(TiAl)(NO)	2	124.50	34.50	3.02
	7	(TiSiV)(NO)	(TiAl)(NO)	4	125.75	34.50	2.98
	8	(TiSiV)(NO)	(TiAl)(NO)	2	124.50	33.75	3.11
	9	(TiSiV)(NO)	(TiAl)(NO)	2	126.75	35.50	2.98
	10	(TiV)(NO)	(TiAl)(NO)	2	117.50	28.75	2.25
	11	(TiV)(NO)	(TiAl)(NO)	2	115.50	27.50	2.15
	12	(TiV)(NO)	(TiAl)(NO)	2	118.75	28.25	2.11
	13	(TiV)(NO)	(TiAl)(NO)	2	109.50	27.75	2.20
	14	(TiV)(NO)	(TiAl)(NO)	8	110.75	28.50	1.92
	15	(TiV)(NO)	(TiAl)(NO)	2	107.50	27.75	1.99
	16	(TiV)(NO)	(TiAl)(NO)	6	98.75	25.75	2.12
	17	(TiV)(NO)	(TiAl)(NO)	10	103.50	26.75	2.15
	18	(TiV)(NO)	(TiAl)(NO)	2	95.66	24.75	1.95
	19	(TiV)(NO)	(TiAl)(NO)	16	102.25	26.25	1.98
比較例	20	(TiSiV)(NO)	(TiAl)(NO)	2	45.50	9.75	1.12
	21	(TiSiV)(NO)	(TiAl)(NO)	2	45.75	8.75	1.08
	22	(TiSiV)(NO)	(TiAl)(NO)	5	59.50	8.50	1.09
	23	(TiV)(NO)	(TiAl)(NO)	7	48.75	9.80	1.12
	24	(TiV)(NO)	(TiAl)(NO)	2	58.50	8.75	0.85
	25	(TiV)(NO)	(TiAl)(NO)	6	36.75	5.25	0.55
	26	(TiV)(N)	(TiAl)(N)	2	61.25	11.50	1.24
	27	(TiSiV)(N)	(TiAl)(N)	2	60.50	12.25	1.27
	28	(TiSiV)(N)	(TiAl)(NO)	2	61.50	10.75	1.09
	29	(TiV)(NO)	−	1	22.50	2.25	0.77
	30	(TiSiV)(NO)	−	1	18.50	3.25	0.25
	31	−	(TiAl)(NO)	1	57.75	13.50	1.35
従来例	32	(Ti)(N)		1	31.50	4.50	1.12
	33	(Ti)(CN)		1	46.50	4.20	1.46
	34	(TiAl)(N)		1	42.50	12.75	1.35

【0021】得られた硬質皮膜被覆エンドミルおよび硬質皮膜被覆インサートを用い切削試験を行った。工具寿命は刃先の欠けないしは摩耗等により工具が切削不能となった時の切削長とした。切削諸元を次に示す。

【0022】2枚刃エンドミル切削条件は、側面切削ダウンカット、被削材S50C（硬さ220HB）、切り込みAd10mm×Rd1mm、切削速度250m／min、送り0．06mm／tooth、エアーブロー使用、とした。

【0023】6枚刃エンドミル切削条件は、側面切削ダウンカット、被削材SKD11（硬さ62HRC）、切り込みAd8mm×Rd0．4mm、切削速度150m／min送り0．03mm／tooth、エアーブロー使用、とした。

【0024】インサート切削条件は、工具形状SEE42TN、巾100mm×長さ250mmの面取り加工、被削材SKD61（硬さ45HRC）、切り込み2．0mm、切削速度150m／min、送り0．15mm／rev、乾式切削とした。表1に試験結果を併記する。

【0025】比較例20、21は夫々Si、Vの量が多すぎる場合の比較例であり皮膜剥離により工具寿命が短い。比較例22は、Vの量が少なすぎる場合の比較例であり、皮膜の耐酸化性が十分でなく工具寿命が短い。比較例23は，Vの量が多すぎる場合の比較例で，皮膜の硬度低下が顕著であり逃げ面摩耗が大きく耐摩耗性が悪い。比較例24はVの量が少なすぎる場合の例で摩擦による刃先温度上昇に伴い溶着が起こり被削面が荒れ、十分な耐摩耗性を示さない。比較例25は、酸素添加量が多過ぎる場合であり、十分な皮膜硬度が得られず逃げ面摩耗が大きくなり寿命が短い。比較例26、27、28はSiおよびVの量は請求項内の範囲であるがA層もしくはB層にOが添加されていない場合の比較例であり、本発明例に比較して耐摩耗性が十分ではない。比較例29、30はA層の単一皮膜であるが、皮膜の剥離が早期に生じ短寿命となった。比較例31はB層の単一皮膜であるが耐摩耗性が十分ではない。

【0026】これらに対し本発明例は、硬質皮膜の、工具として使用した場合の動的耐酸化性に優れ、摩擦による温度の上昇も少なく、また、内部応力、密着力、硬さと靭性のバランスを考慮したB層を併用しているので、剥離によって急激に摩耗が進行することもなく、総合して工具寿命が著しく向上する。本発明は乾式高速切削加工に十分対応するものである。

【0027】

【発明の効果】以上の如く、本発明の硬質皮膜被覆工具は、従来の被覆工具に比べ優れた耐酸化性、低摩擦を有すことから、乾式高速切削加工において格段に長い工具寿命が得られ、切削加工における生産性の向上に極めて有効である。